

Yield Learning and Volume Manufacturing of High Performance Logic Technologies on 200mm and 300mm Wafers

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Intel Corporation**

Overview

- Intel Development and Production Ramp History
- Methods
- 130nm Process Results: 200mm
- 130nm Process Results: 300mm
- Conclusions

Overview

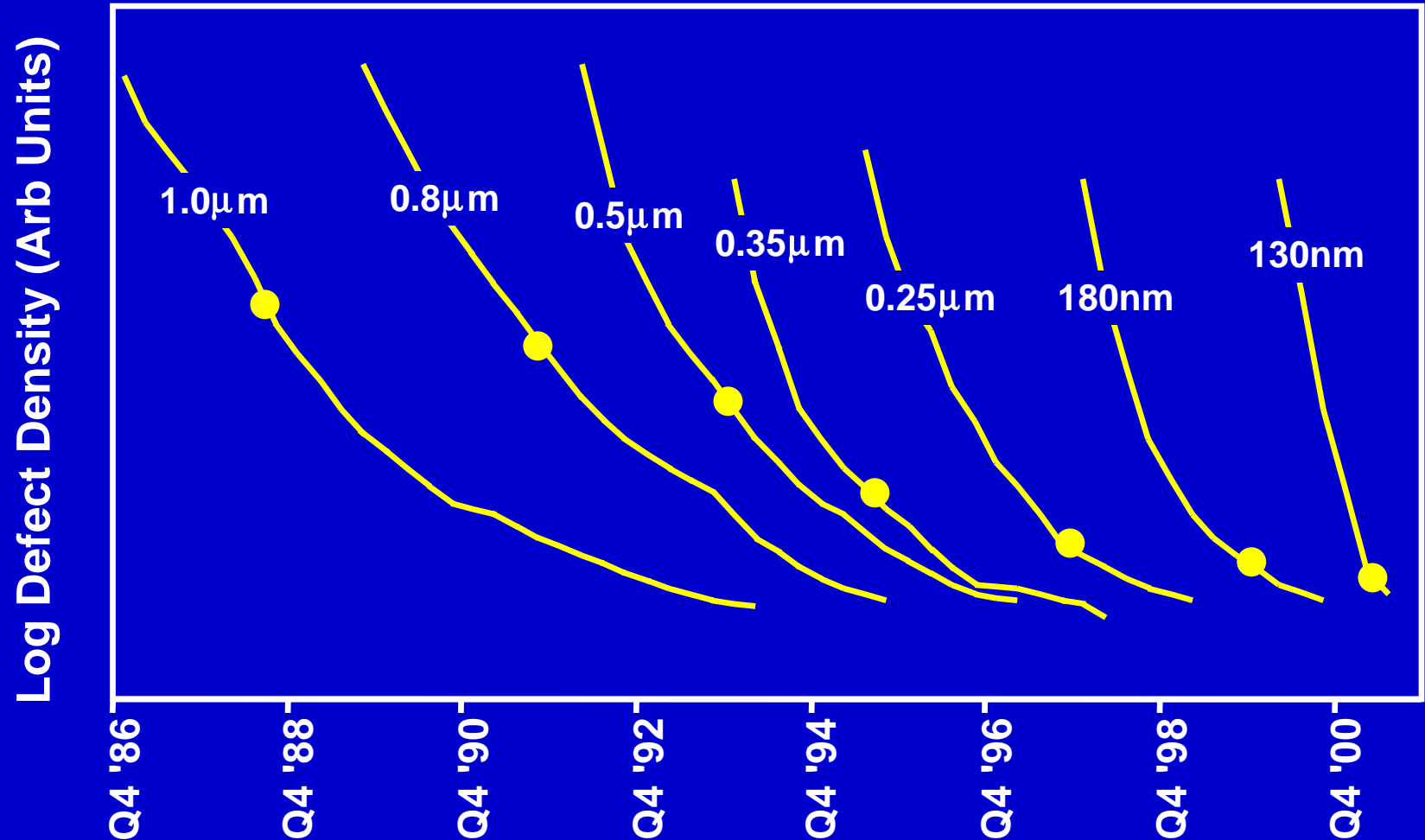
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- **Conclusions**

Introduction

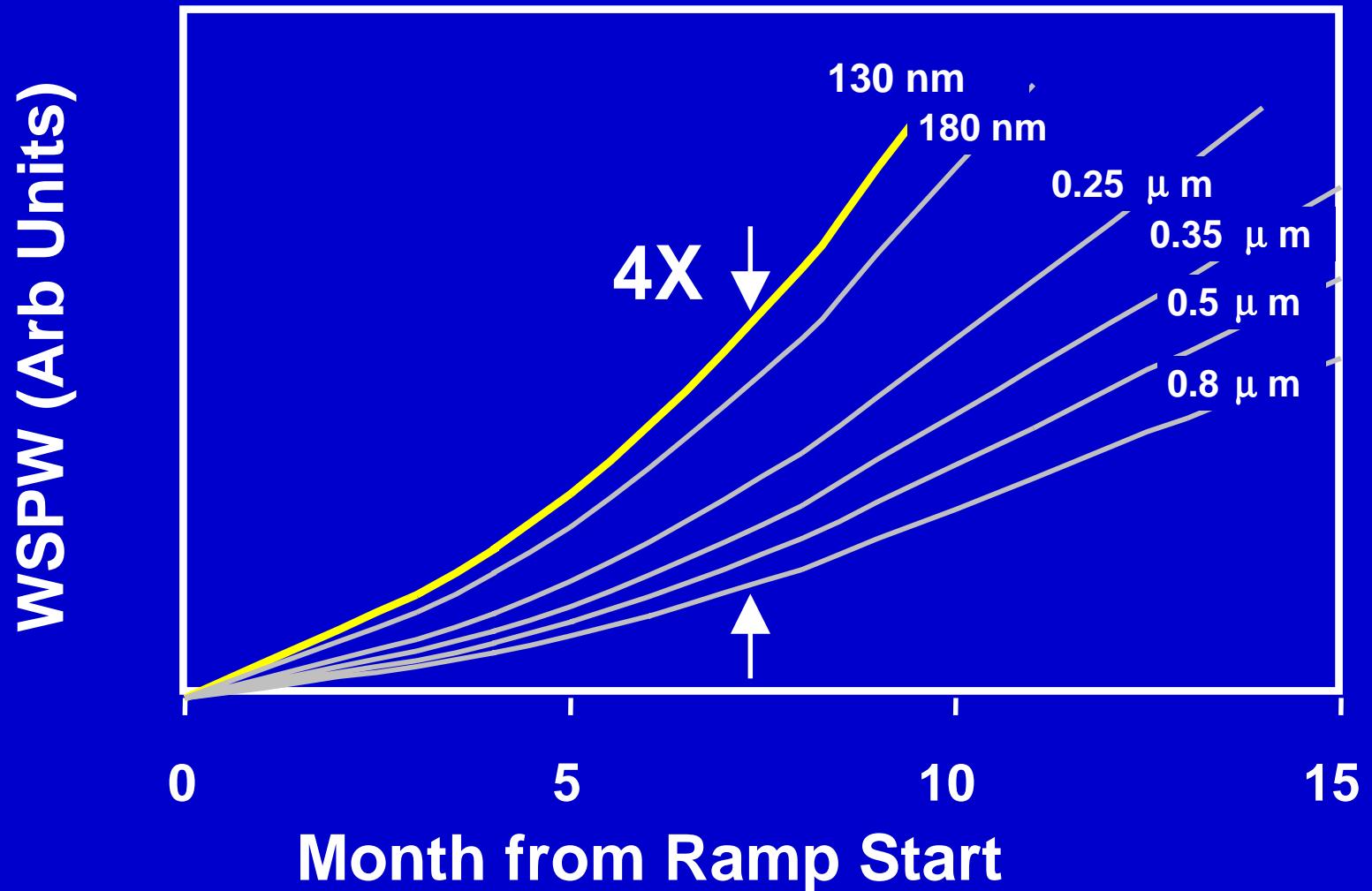
- Products on new processes are more competitive
- Anything modulating ramp dramatically impacts manufacturing competitiveness
 - ramp timing, ramp rate, die yield, etc

Bottom Line: Be first in high volumes

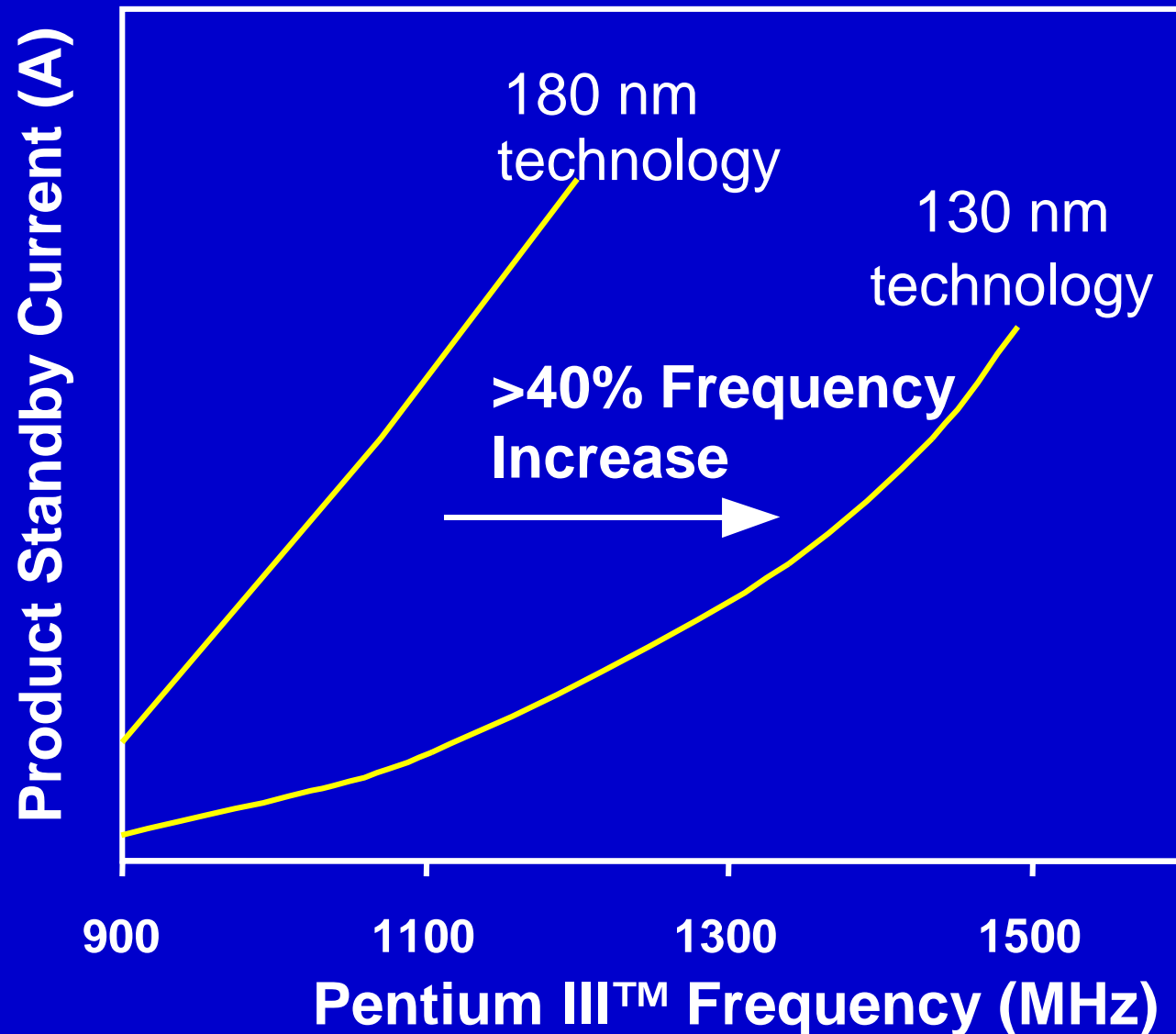
Technology Development Yield Learning Rates



Manufacturing Ramp Rates



Product Performance



Overview

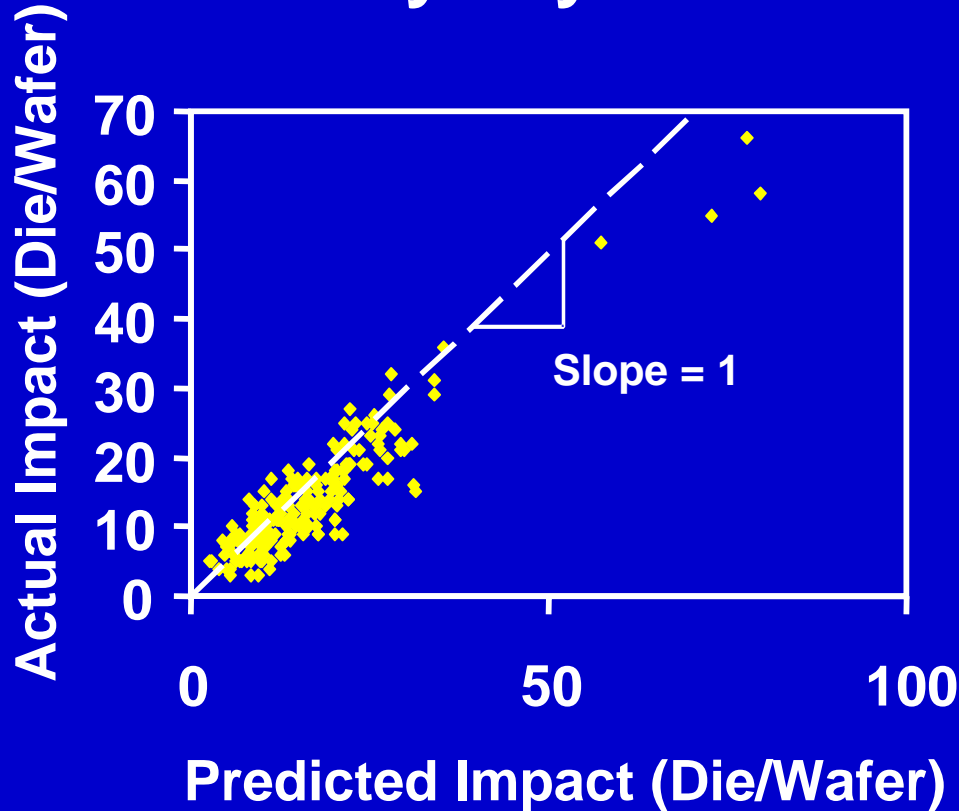
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Methods

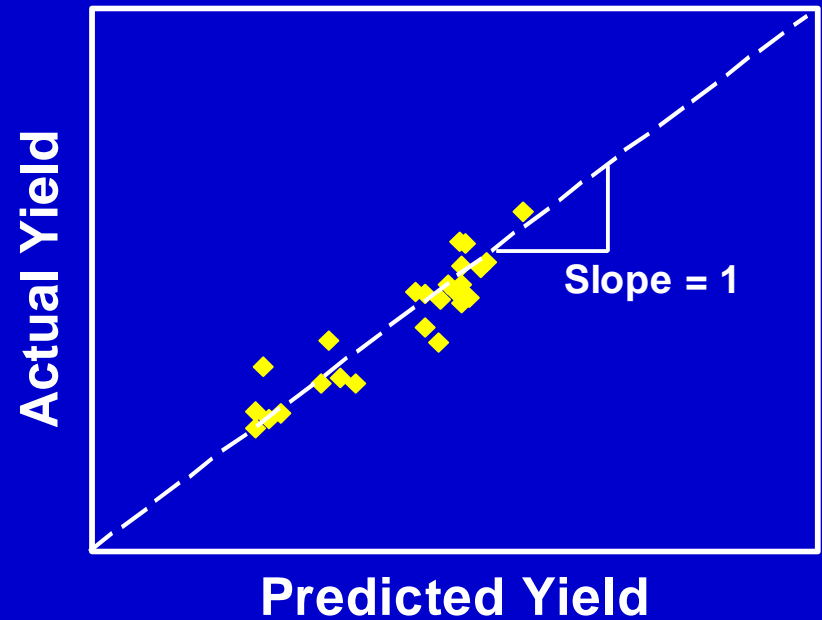
- **Yield Predictive In-line Metrology**
- **Design for Manufacturing and Performance**
 - **Proprietary Materials**
 - **Advanced Process Control**
- **Copy Exactly! Process Transfer**

Yield Predictive In-Line Metrology

By Layer

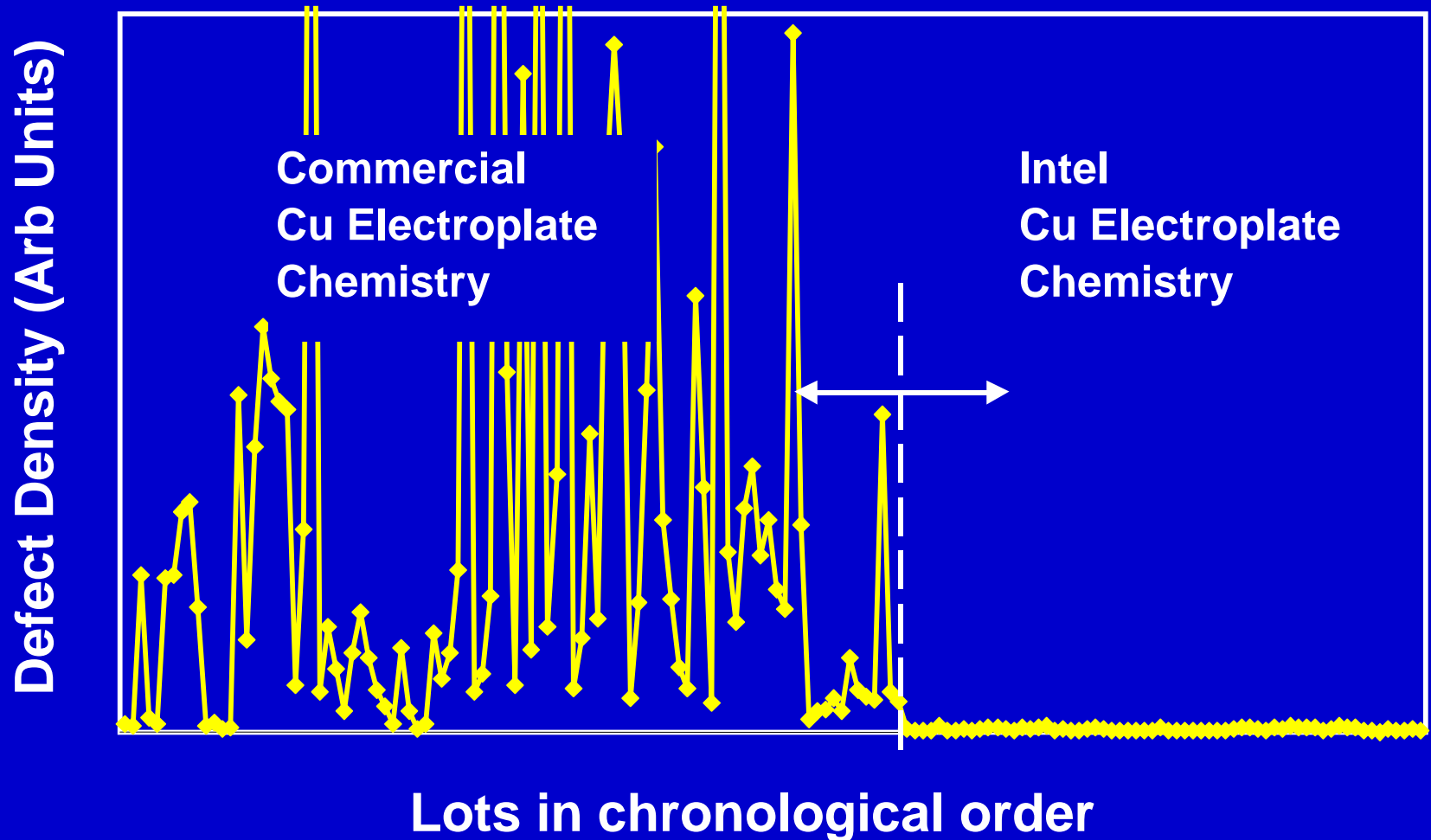


By Work Week



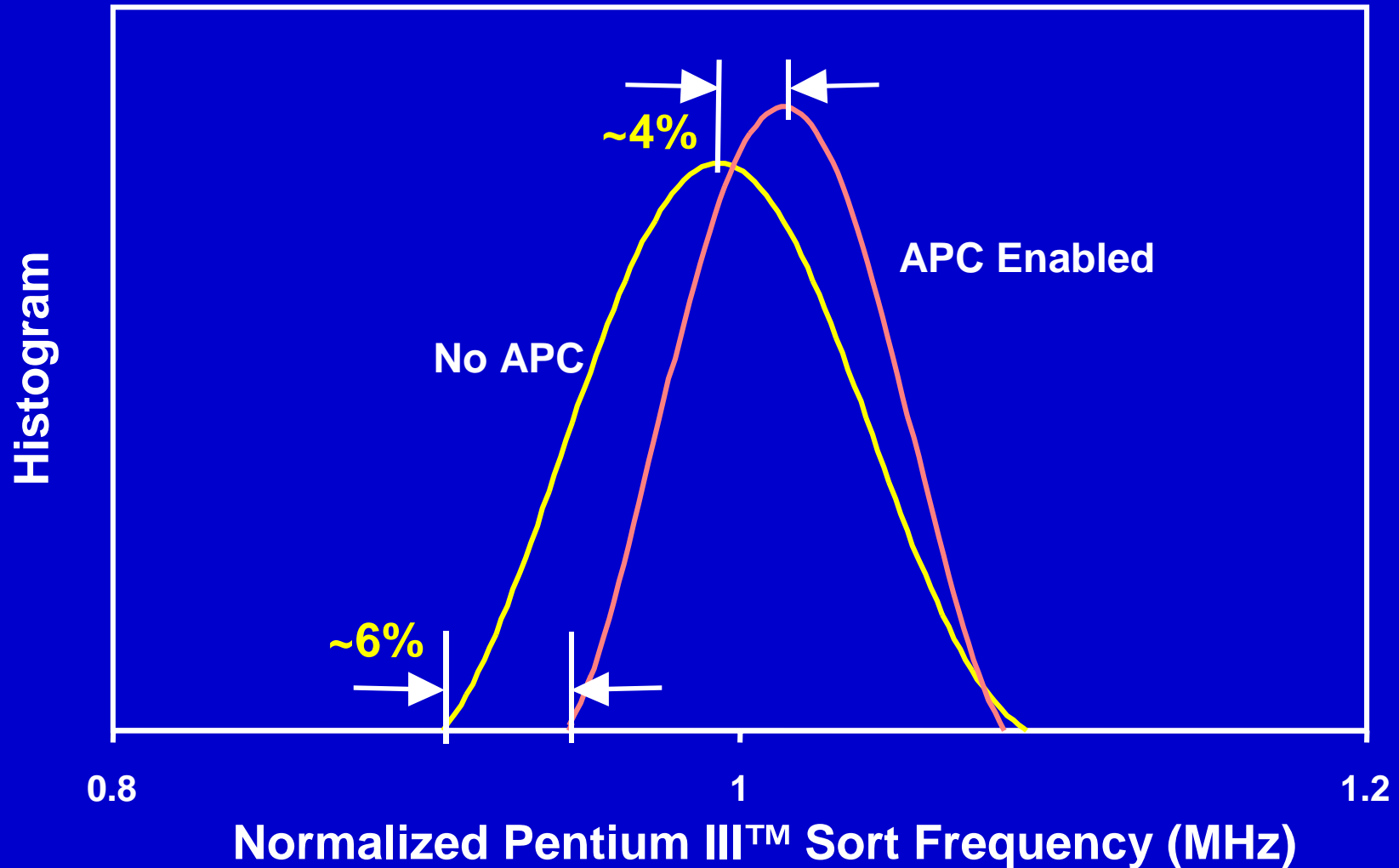
Design For Manufacturing

Proprietary Materials



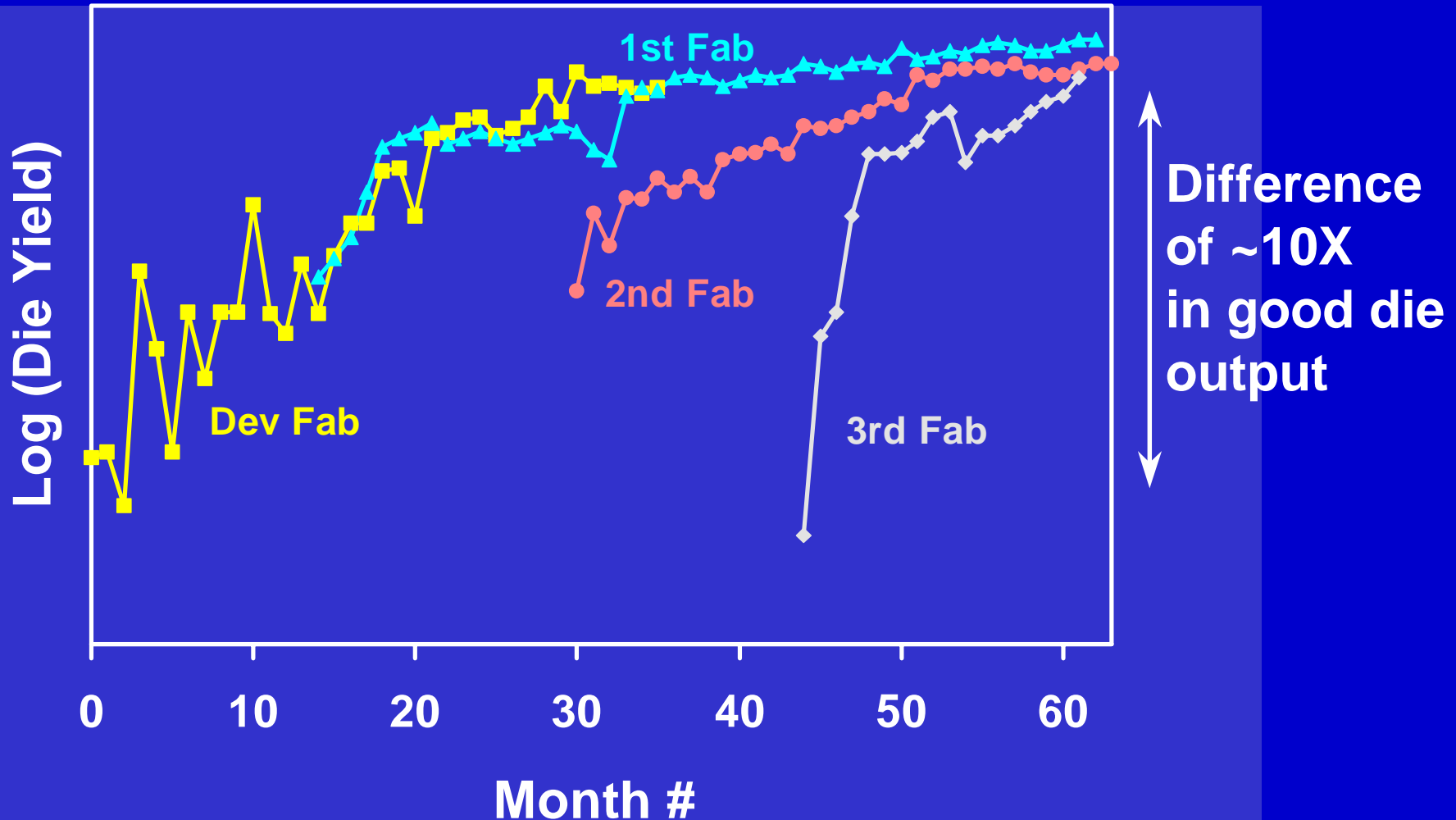
Design For Manufacturing

Advanced Process Control



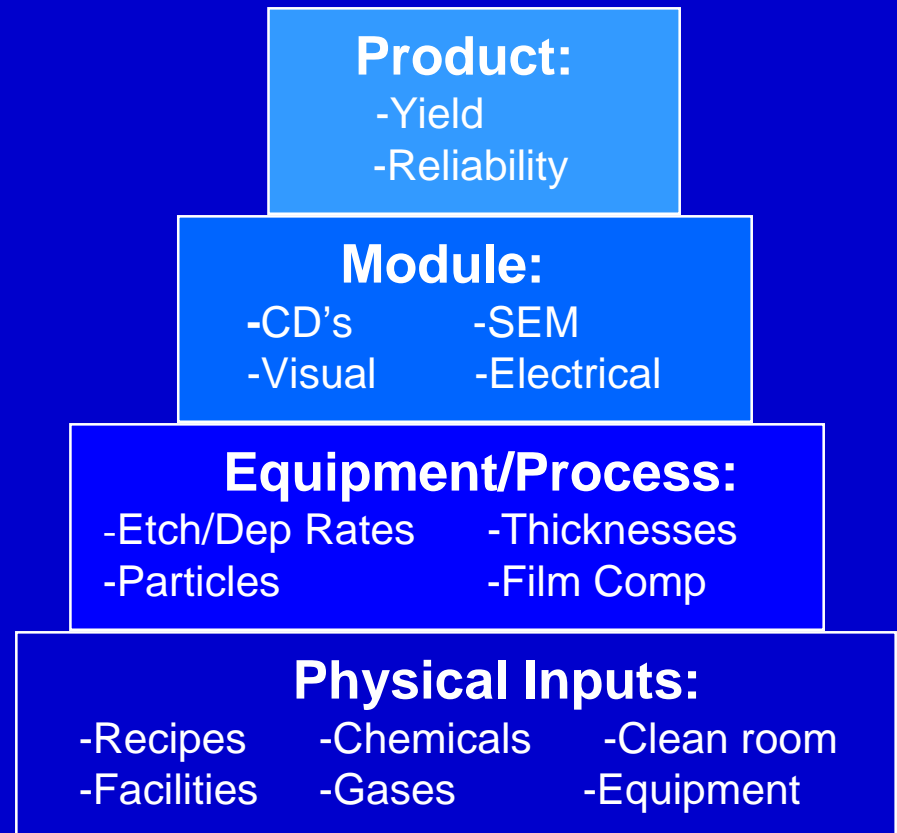
The Birth of Copy Exactly!

Intel 1 μ m Process



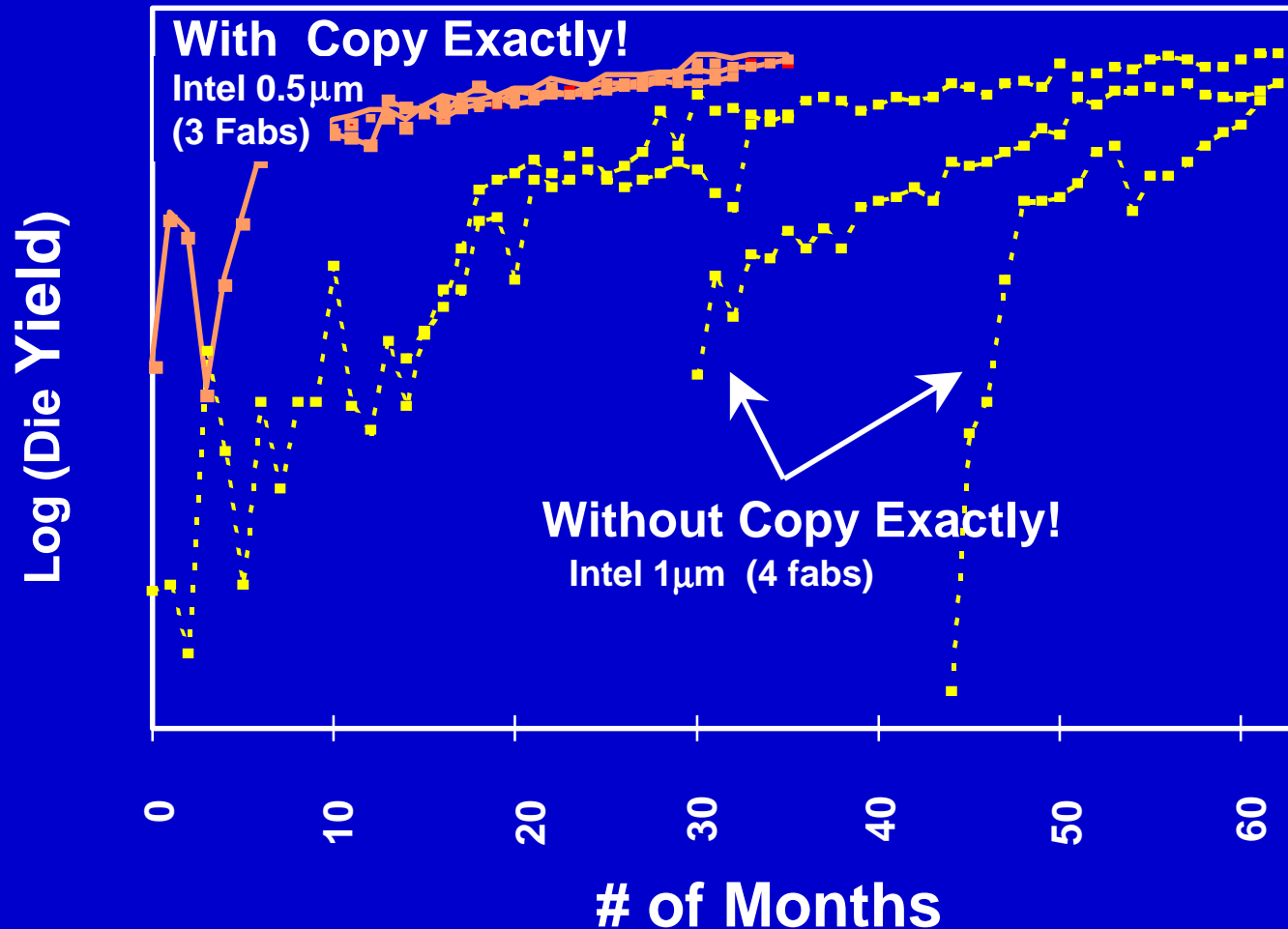
Copy Exactly! Method

- **Matching at all levels**
 - same physical inputs
 - statistically matched responses (outputs)
- **Keeping matched**
 - coordinated changes
 - audits
 - process control system
 - joint fab mgmt structure



Copy Exactly! Results

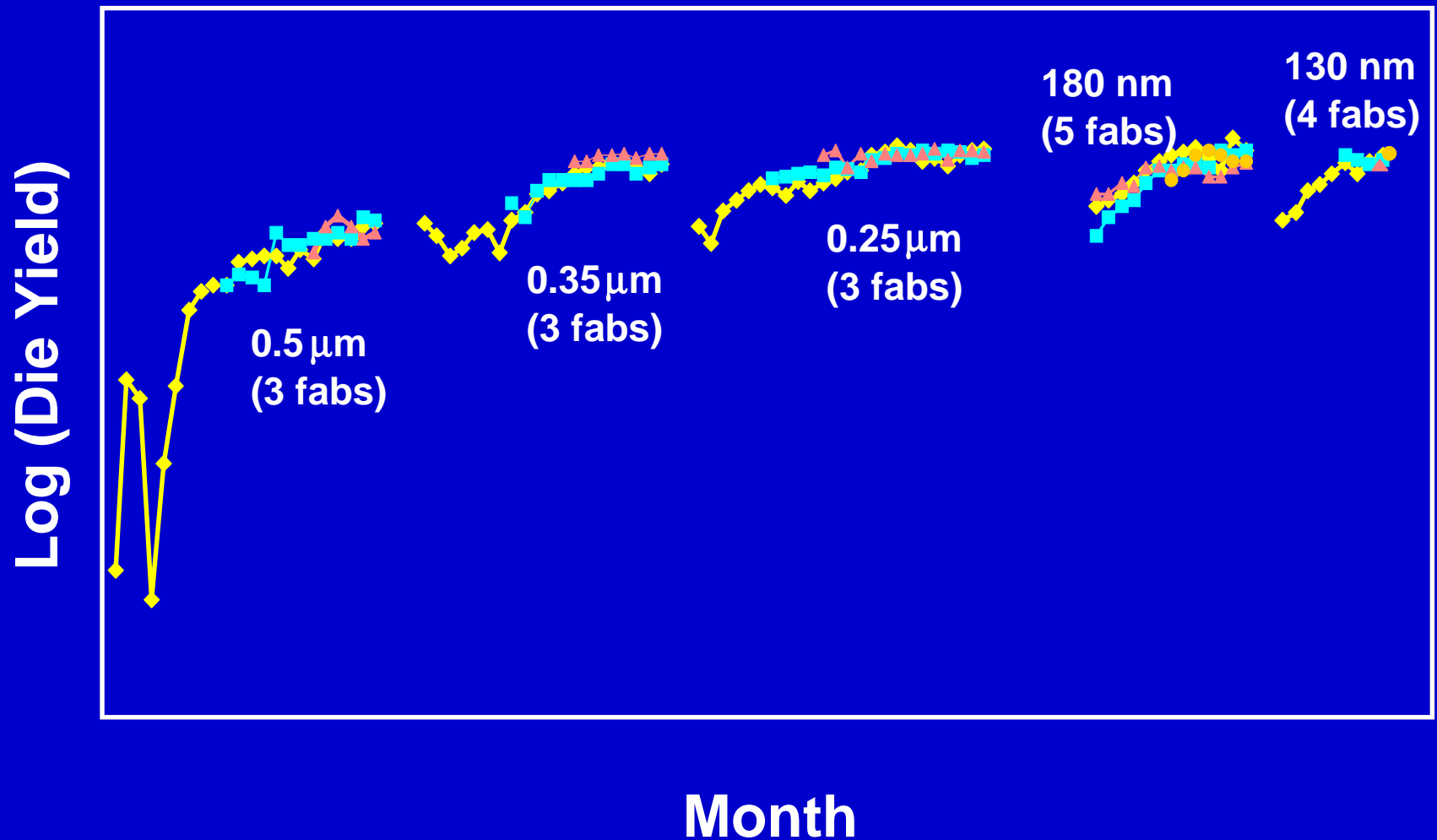
Die Yield Comparison - With/Without CE!



Overview

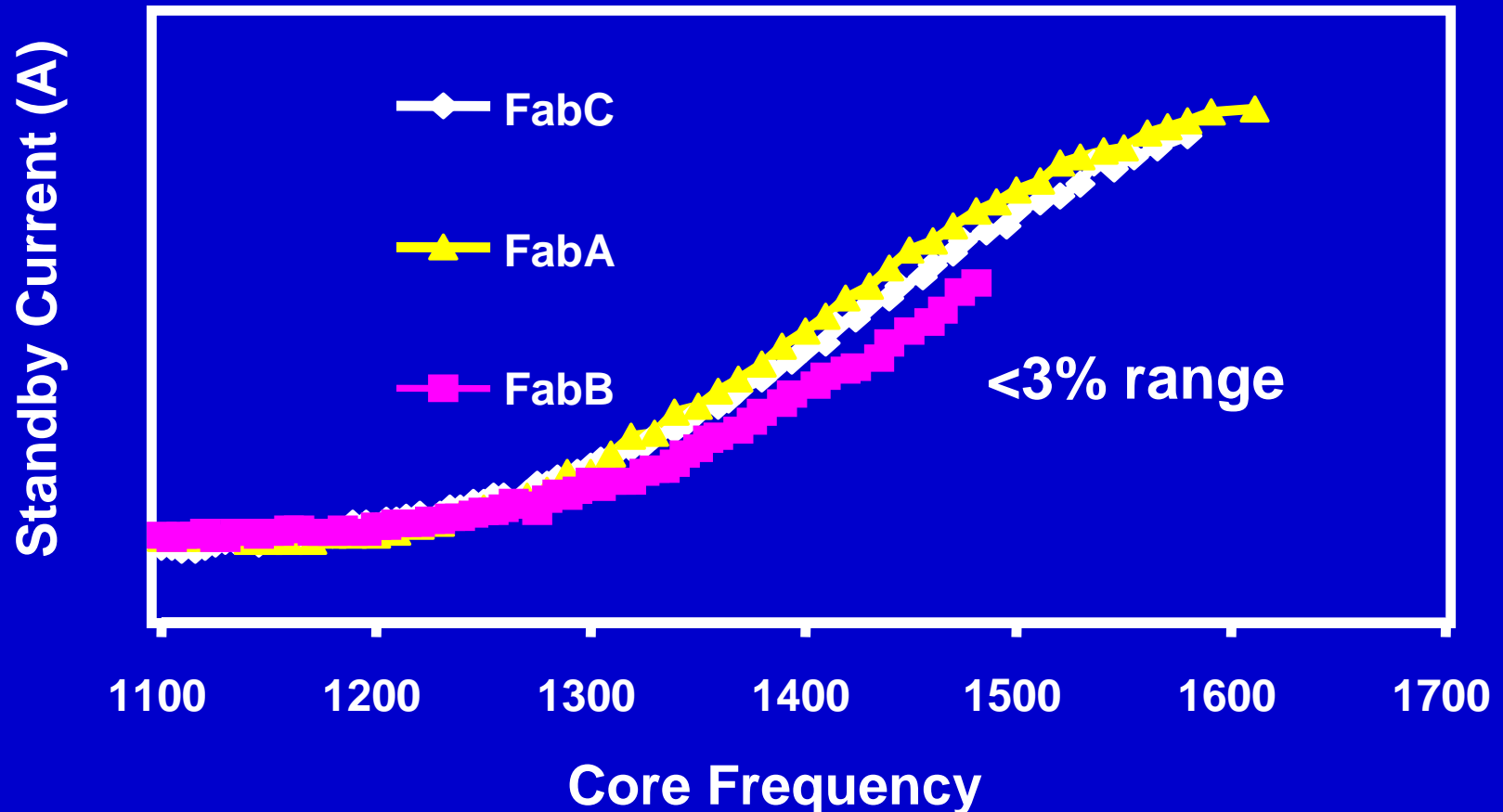
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200mm Yield Matching



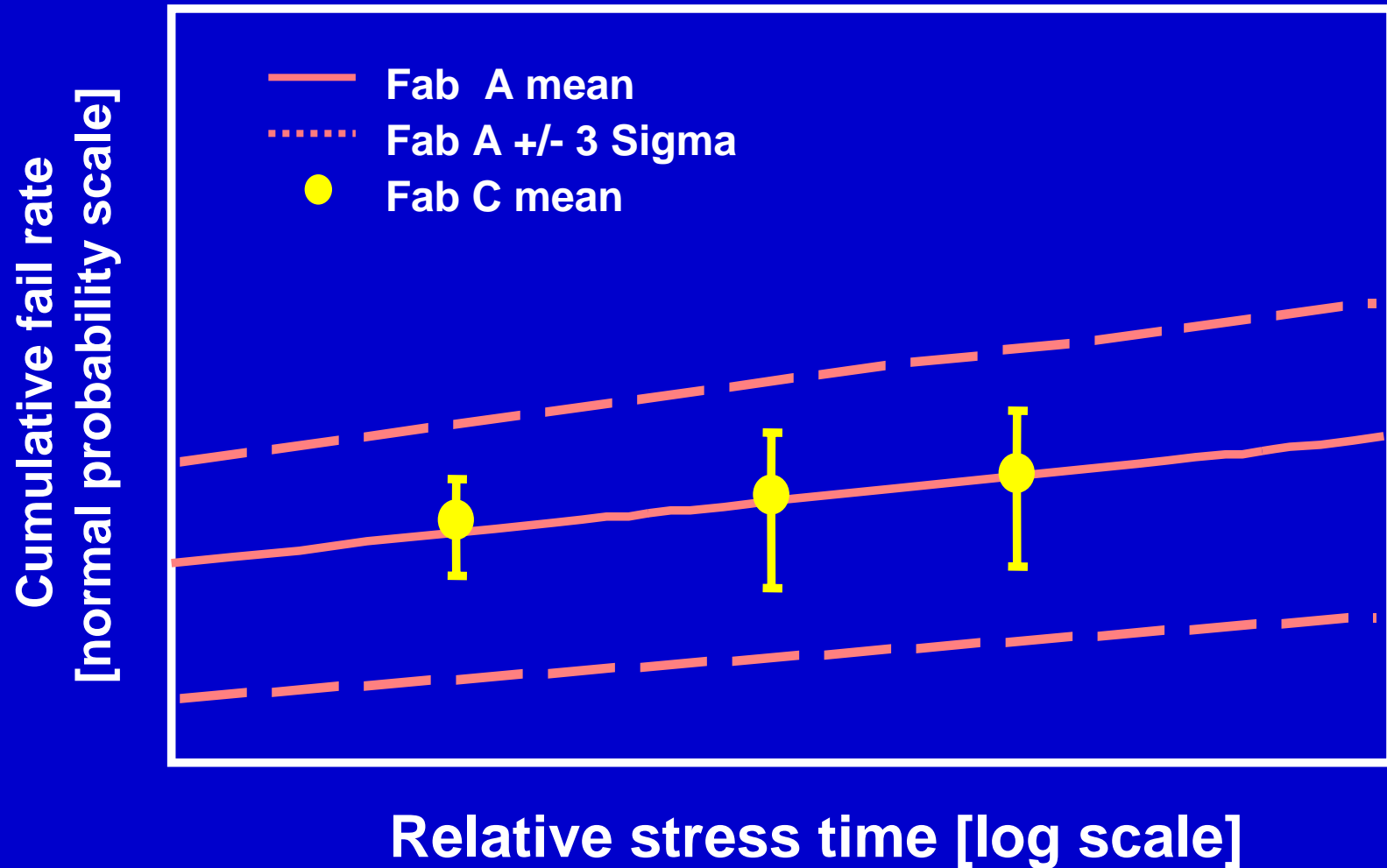
130nm Tech Performance Matching

Pentium III™ Frequency



130nm Tech Reliability Matching

Pentium™ III Burnin



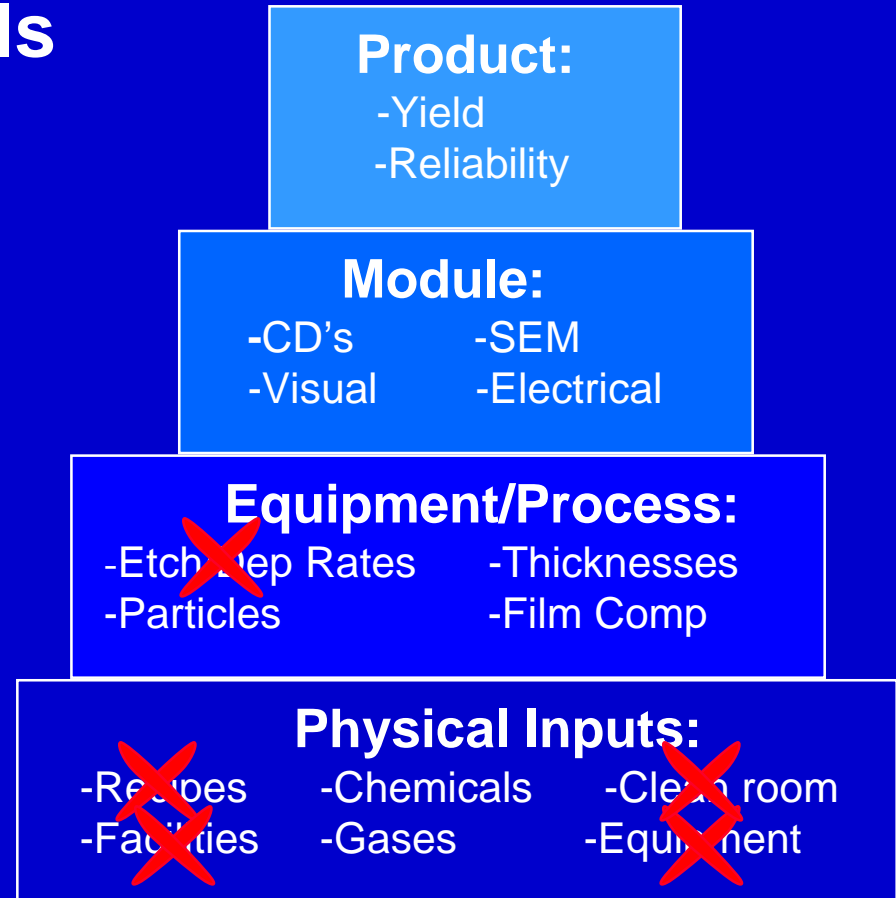
Overview

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Modified Copy Exactly! Method

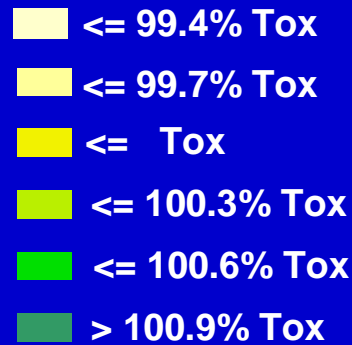
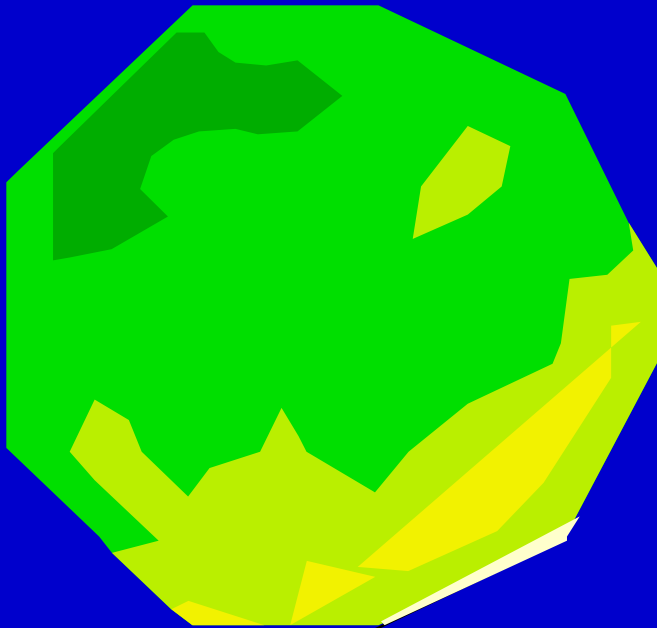
200mm to 300mm

- **Matching at most levels**
 - statistically matched responses (outputs)
 - same process flow and materials
 - hierarchical recipe change method
- **Keeping matched**
 - Only form/fit/function changes

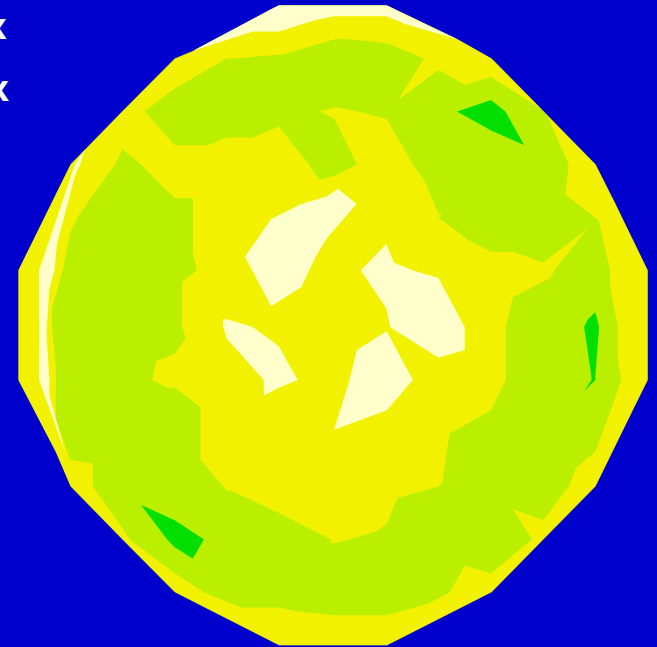


Frontend IL Monitor Matching Gate Oxide

200mm WIW
Range 1.5%



300mm WIW
Range 1.2%



Backend IL Monitor Matching

Post Cu CMP

200mm WIW

Std Deviation = 5.0%

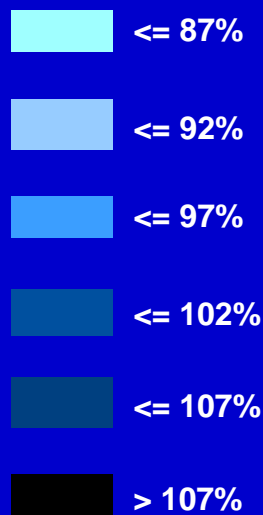
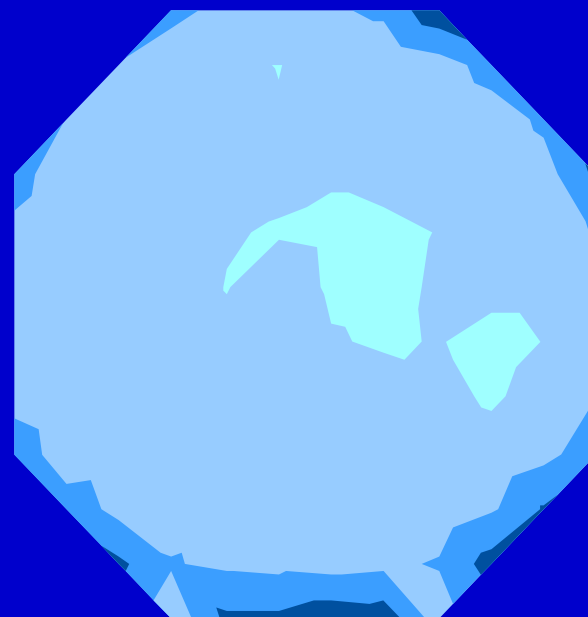
Range = 17.9%



300mm WIW

Std Deviation = 3.6%

Range = 15.7%

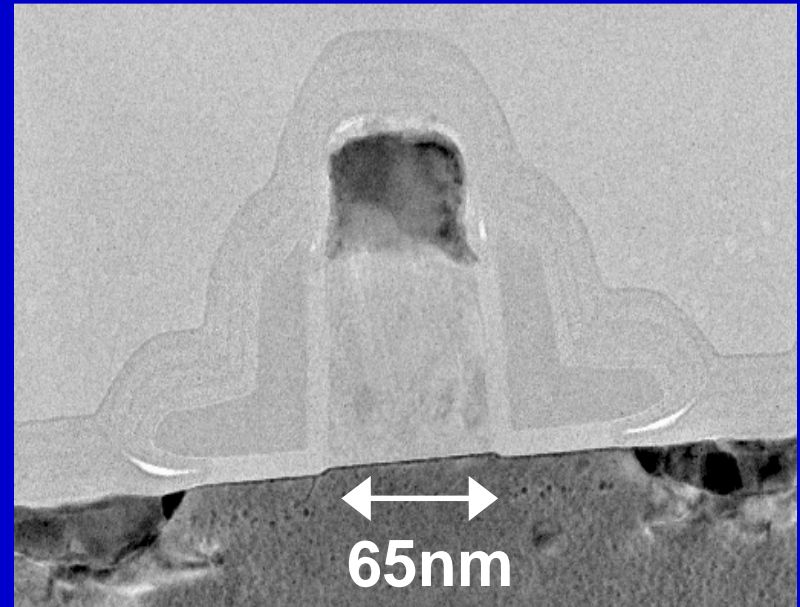
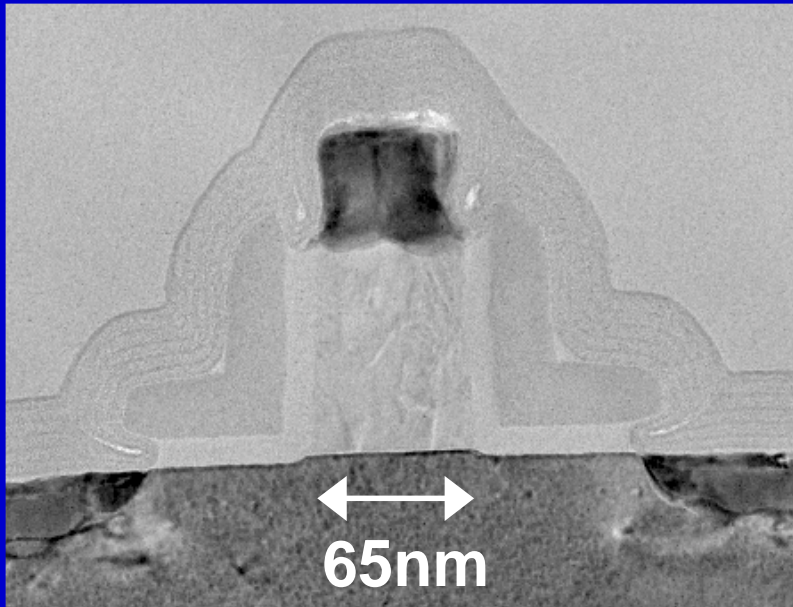


Transistor Matching

TEM Cross-section

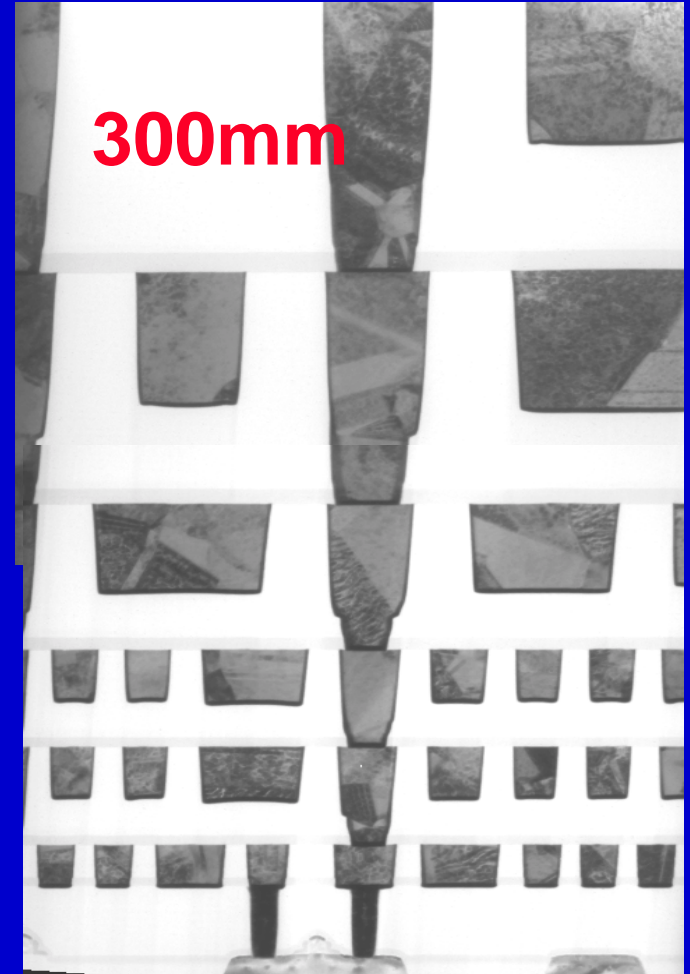
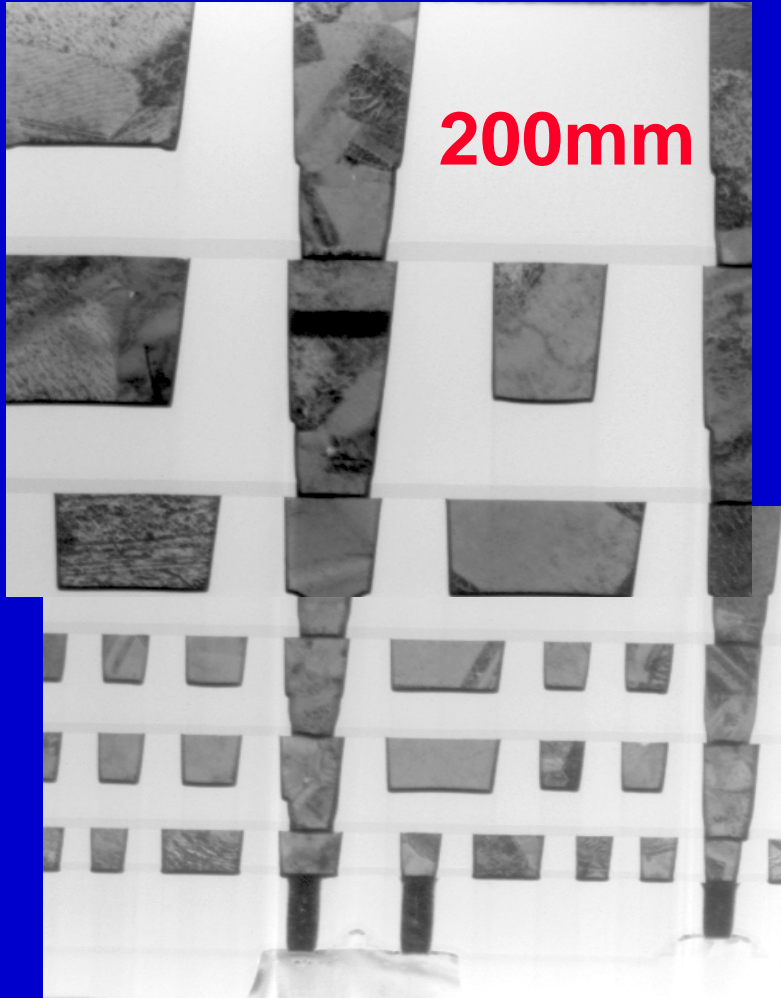
200mm

300mm



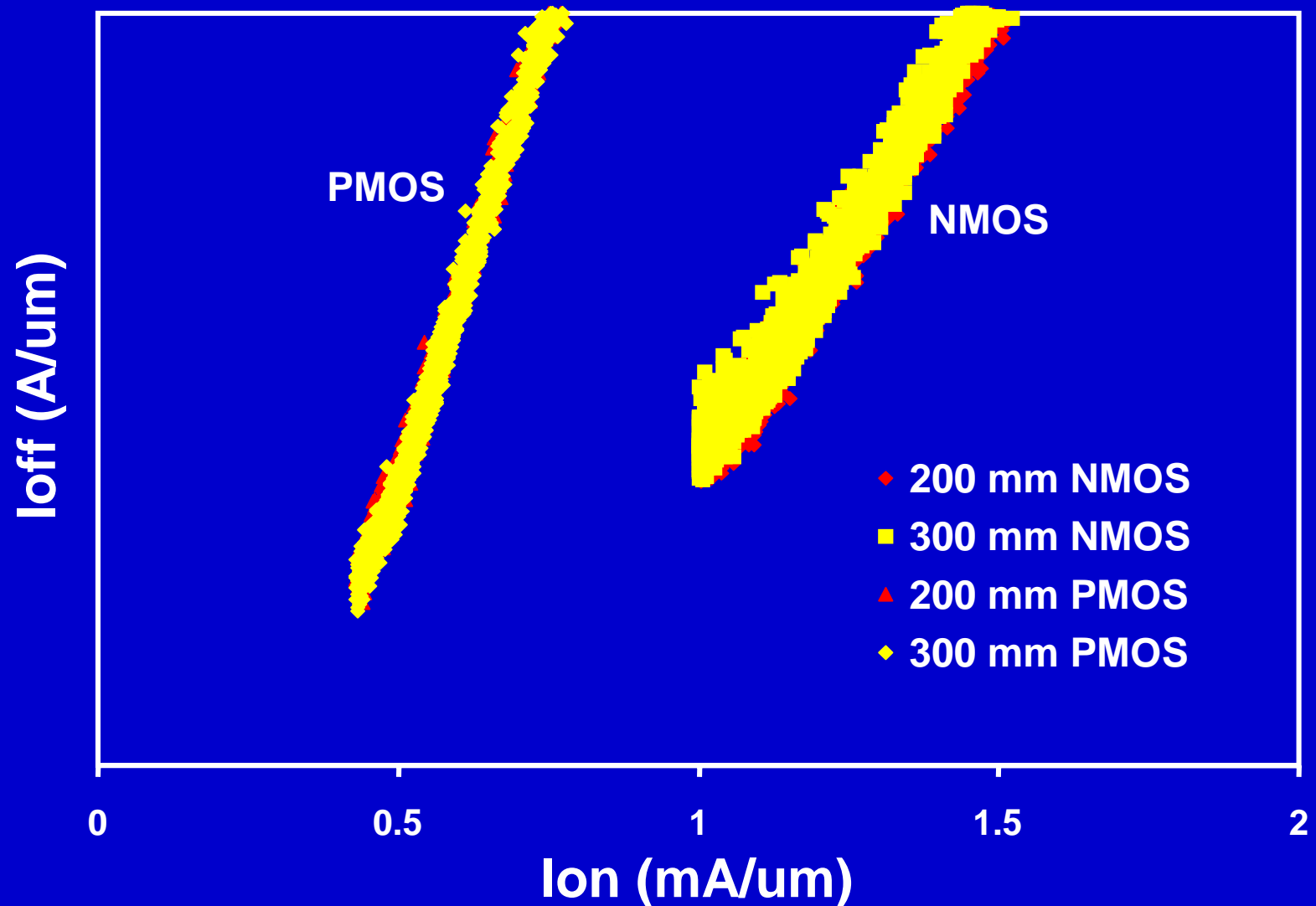
Interconnect Matching

TEM Cross-section

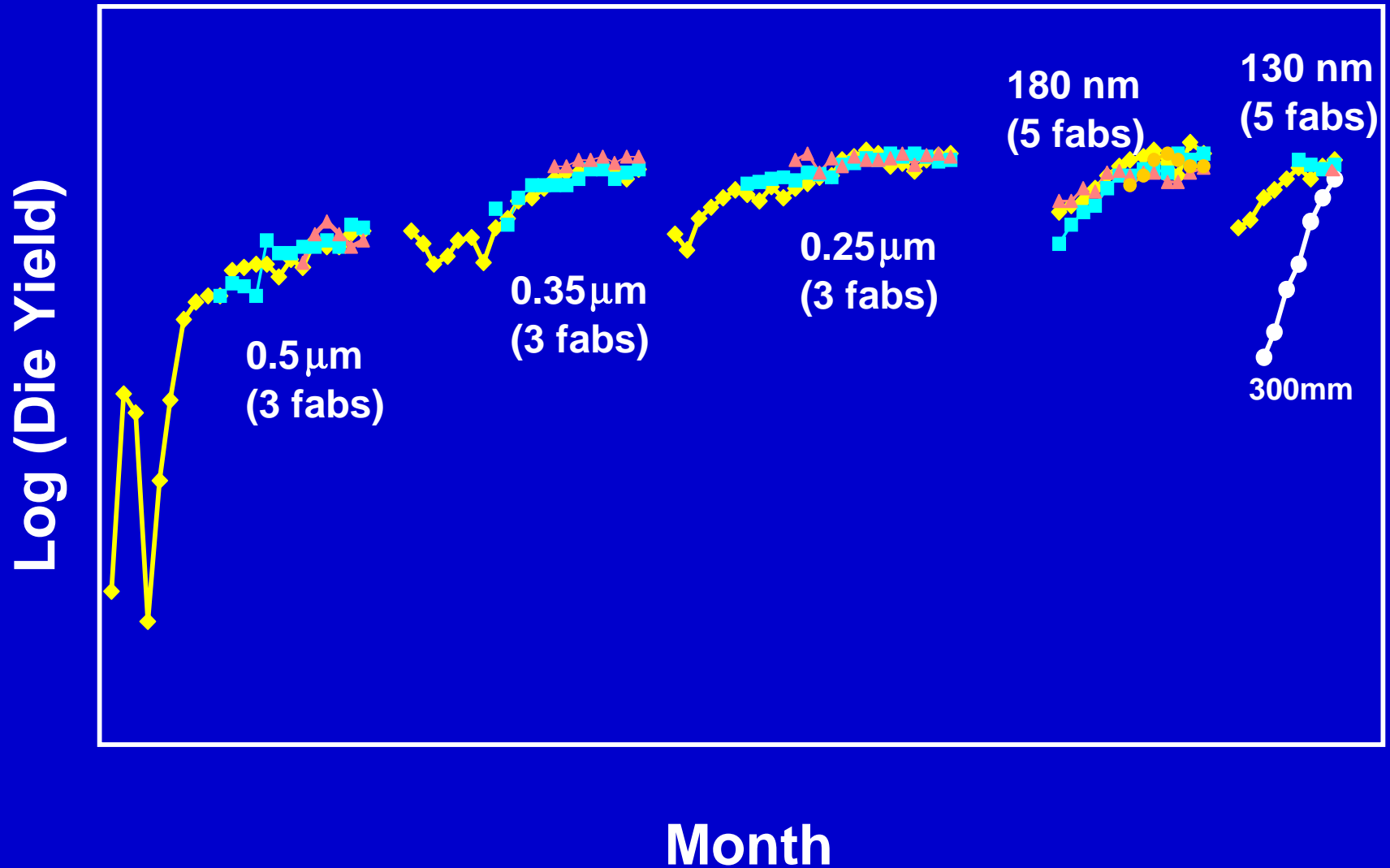


Transistor Matching

I_{on} –vs- I_{off}

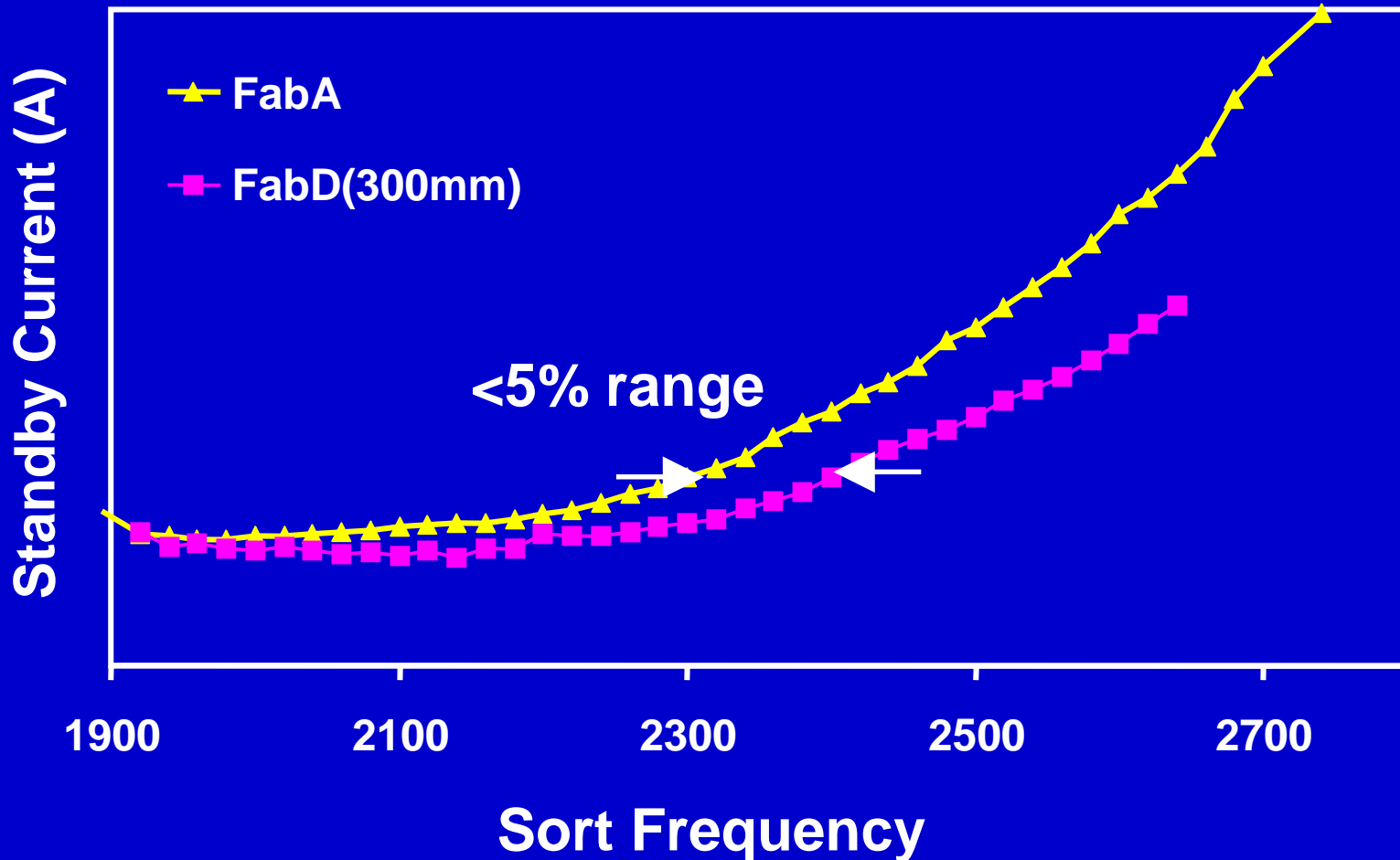


300mm Yield Matching

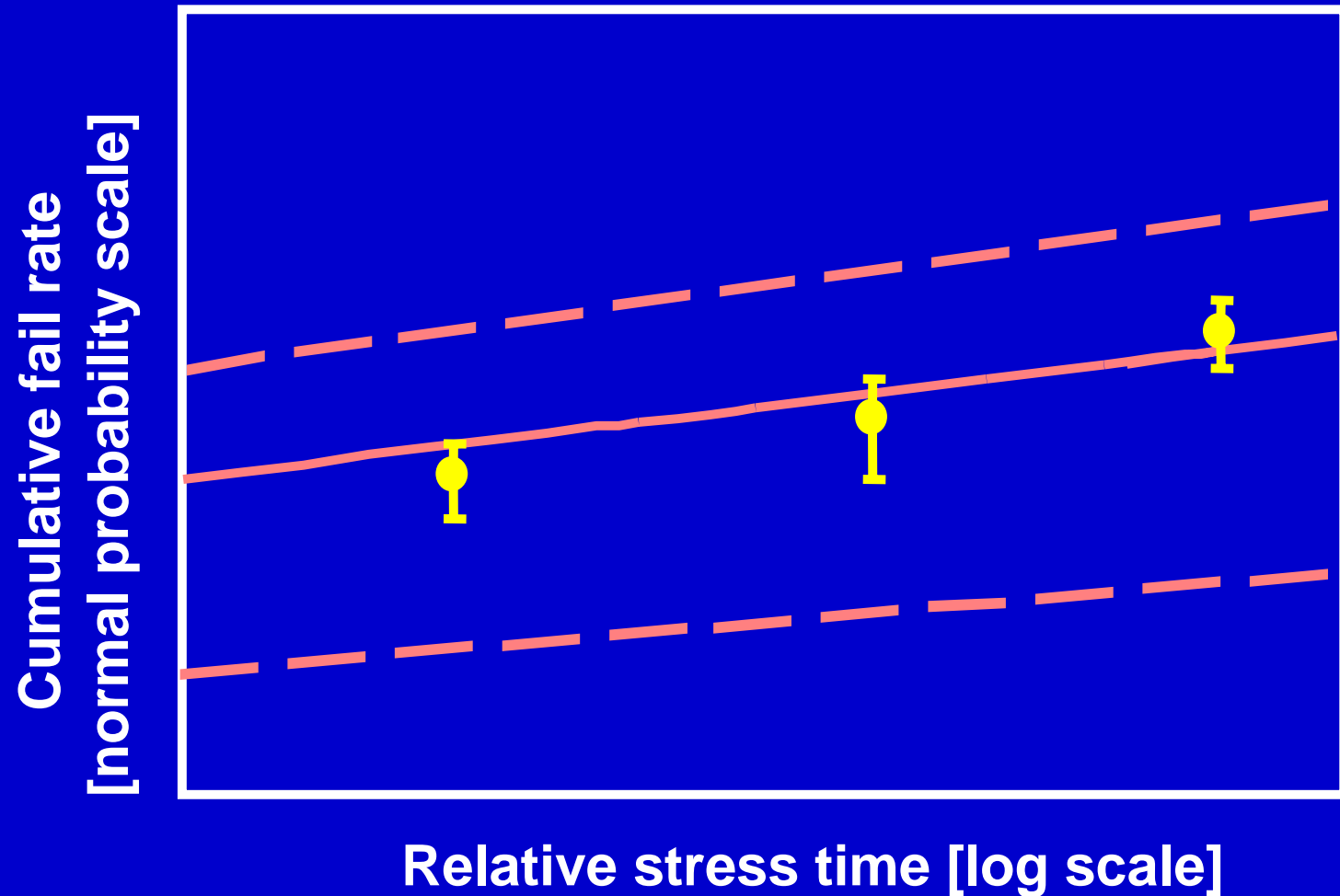


300mm Performance Matching

Pentium IV™ Frequency



300mm Reliability Matching Burnin



Conclusions

- **Ever increasing ramp rate and yield levels for past six Intel technology generations.**
- **Methods**
 - Yield predictive in-line metrology
 - Process design for manufacturing
 - Copy Exactly! process transfer methodologies
- **Five Intel fabs matched and ramping on 130nm process.**
- **World's first 130nm 300mm wafer fab with outstanding matching to the 200mm process.**